
Upgrade of the CEBAF Accelerator to 12 GeV

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Outline

Underlying science motivation

High-level description

Sub-system descriptions

Acceleration

Beam transport

Project Status



CEBAF Science Mission

CEBAF was originally built to establish a deep understanding of the quark/gluon structure of nuclei
(non-perturbative QCD)

The program to date has been highly successful.

New theoretical initiatives have identified critical areas with open questions.

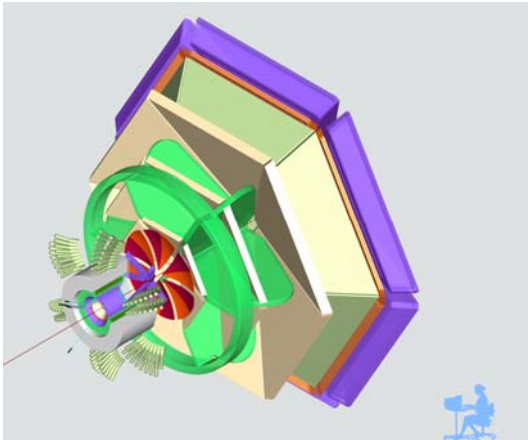
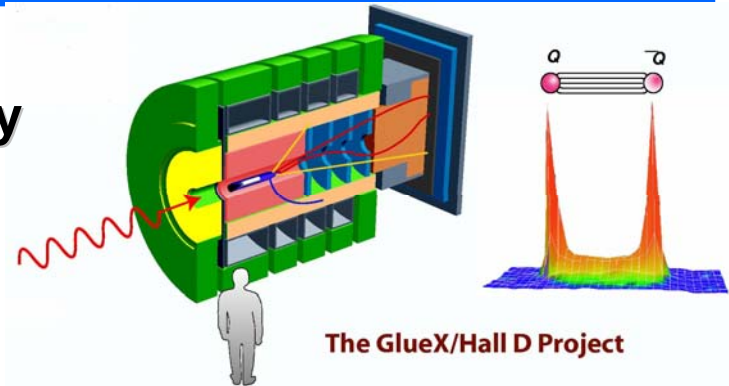
- Quark confinement with exotic meson spectroscopy
- Tomography of the nucleus with GPD's
- Valence quark behavior



Overview of 12 GeV Physics Program

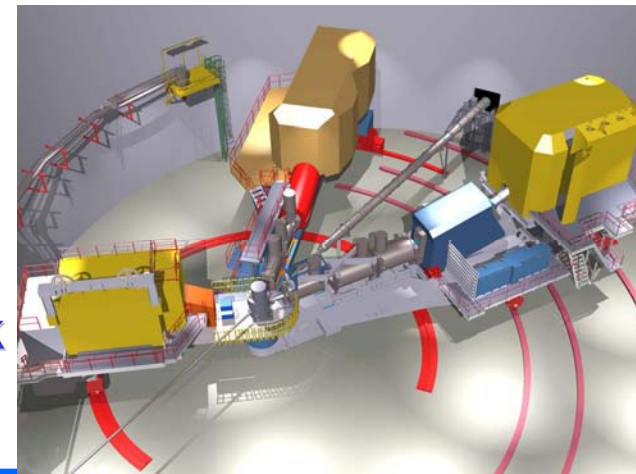
GlueX (Hall D)

Exploring origin of confinement by studying **exotic mesons**



CLAS12 (Hall B)

Understanding nucleon structure via **generalized parton distributions**



SHMS (Hall C)

Precision determination of **valence quark** properties in nucleons and nuclei



DOE Review of the Science Program (April, 2005)

Comments from report

- *“The proposed research in (the fundamental structure of hadrons, the physics of nuclei and fundamental symmetry tests has) high scientific merit...and will not be possible at any other known facility in the foreseeable future, and that significant results of high scientific impact (are) expected to emerge from the program in both in the near and long term.”*
- *The overall proposed program represents an impressive coherent framework of research directed towards one of the top frontiers of contemporary science: the exploration of confinement, a unique phenomenon of the Strong Interaction, one of the four fundamental forces of nature.*
- *“The 12 GeV Upgrade will make TJNAF the world center for research in this area for at least a decade following the start of operations...”*

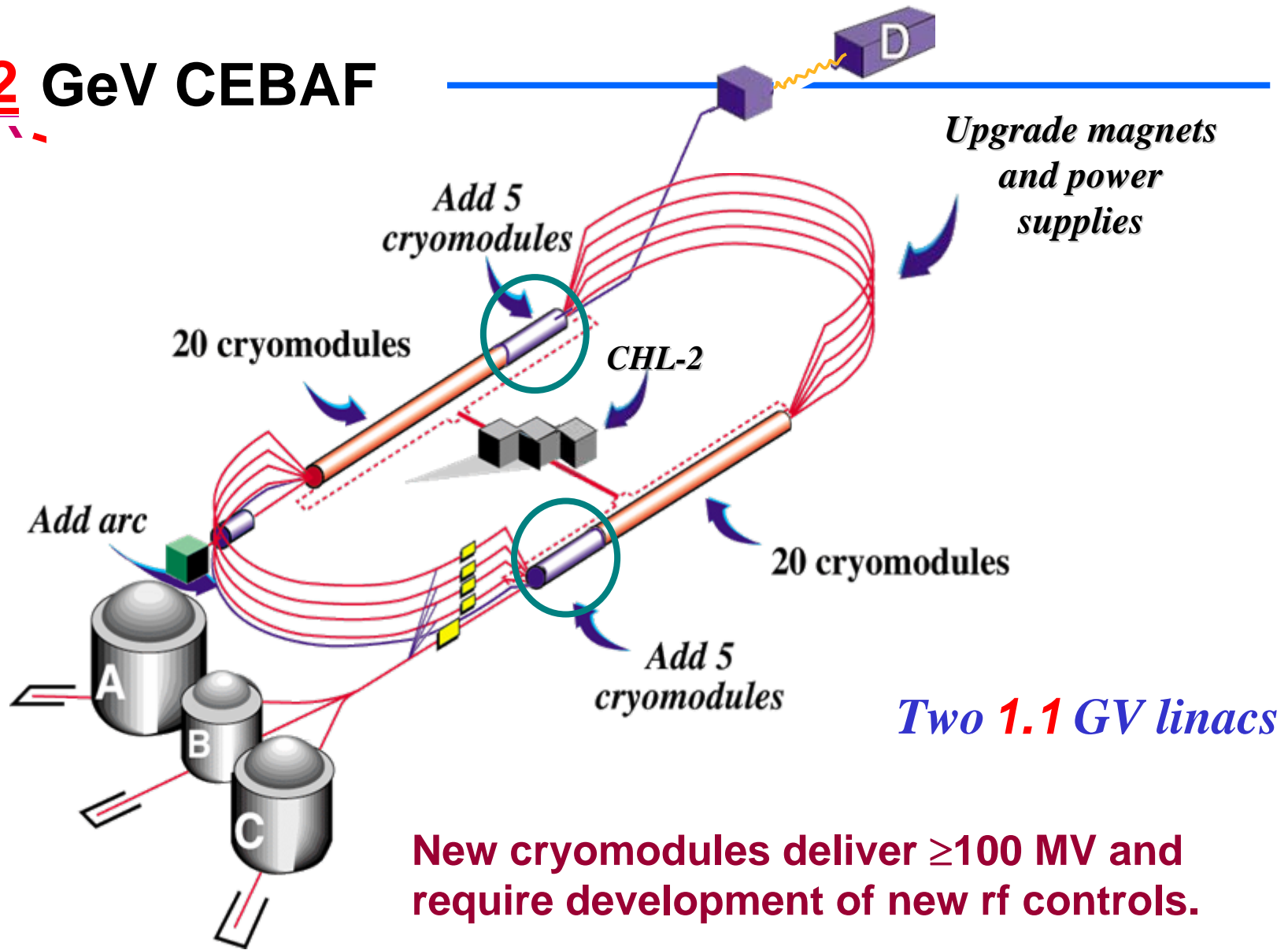


High-level Parameters

	<u>Now</u>	<u>Upgrade</u>
Beam energy	6 GeV	12 GeV
Voltage of each linac	0.6 GV	1.1 GV
Number of recirculations	5	5 ½
Beam power (total program)	1 MW	1 MW
Beam current (hybrid mesons)	-	5 µA
Emittance	1 nm-rad	7 nm-rad
Energy spread	0.01%	0.02%



12 GeV CEBAF



Cryomodule Voltage and Cavity Gradient

What is needed?

- Present: $6 \text{ GeV} / 5 \text{ passes} = 1.2 \text{ GeV/pass} = 0.6 \text{ GeV/linac}$
 - 12 GeV: $12 \text{ GeV} / 5.5 \text{ passes} = 2.2 \text{ GeV/pass} = 1.1 \text{ GeV/linac}$
- ⇒ Need to add 0.5 GV/linac

Adding 0.5 GV/linac

- There are 5 empty zones at the end of each linac
- We're "there" if we install a 100 MV cryomodule in each zone.

"100" MV cryomodules

- Exact requirement is 98 MV (average for each linac)
 - Add ~10% for operational contingency ⇒ 108 MV/cryomodule
 - 8 cavities/cryomodule
 - 7 $\lambda/2$ cells per cavity
 - 108 MV ÷ 5.6 m = 19.2 MV/m
- } 5.6m



Cryogenics

Existing plant is at full capacity with 6 GeV configuration.

⇒ We must build a new plant.

Have a crucial piece for a 2nd plant.

- Redundant 2K cold-box (identical to primary cold-box)
- After adding a 4K system we get 4.6 kW

Each of the two plants must supply:

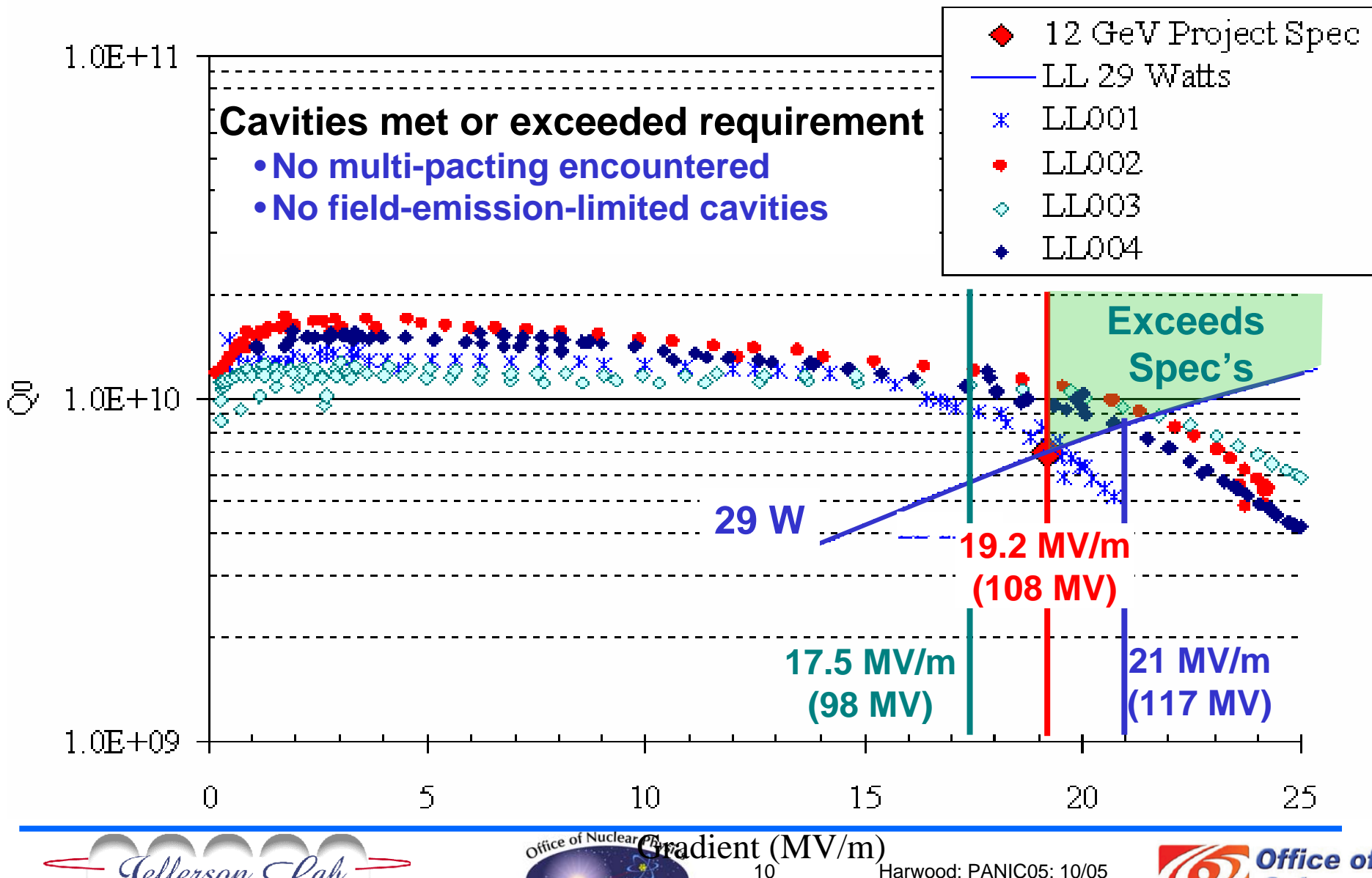
- One existing linac
- New cryomodules
- Reasonable headroom

Available capacity for each new cryomodule

- 2K 300W (allows 29W/cavity of dynamic loss)
- 50K 300W



Cavity Testing



Harwood; PANIC05; 10/05



RF control

High-level performance requirements are the same as 6 GeV

Amplitude noise $<1 \times 10^{-4}$

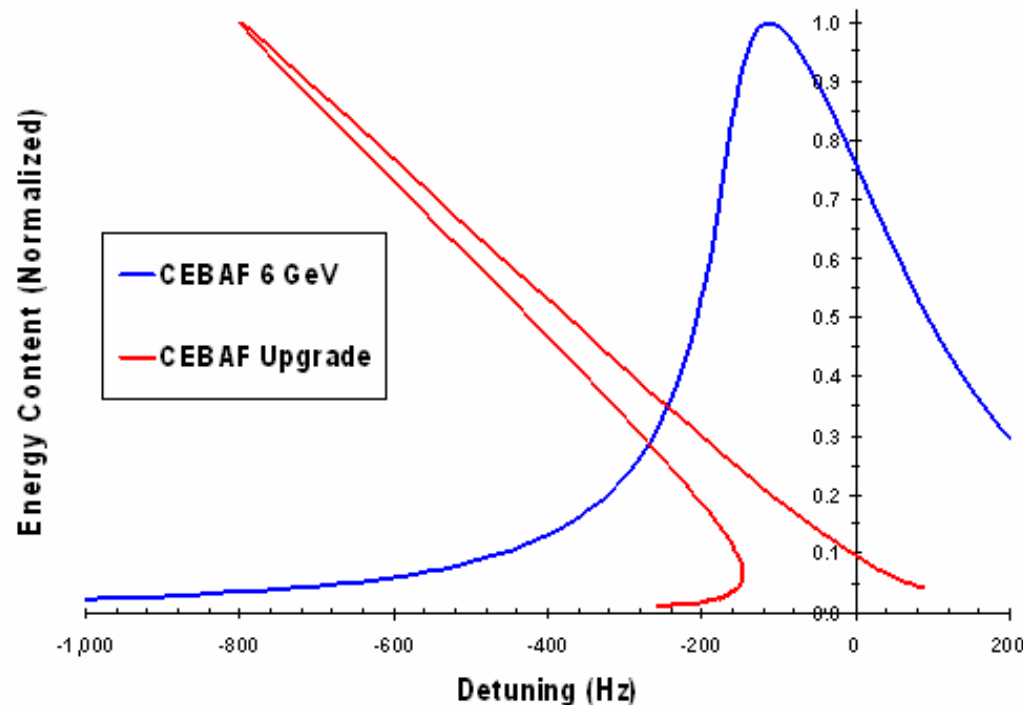
Phase noise $<0.2^\circ$

Must deal with narrow bandwidth and large Lorentz detuning

- $Q_{\text{external}} \geq 2 \times 10^7$
- Stiffness $\approx 1.5 \text{ Hz}/(\text{MV}/\text{m})^2$
 \Rightarrow **Very tilted detuning curve**

Digital system being prototyped

- Collaboration with Cornell
- Technology demonstrator met spec's with & without beam loading.
- Vertical integration test next summer



Beam Transport

The principal challenge

Not replace everything when the beam energy is 2x the design envelope for the magnets and power supplies.

Magnets

- ~2100 magnets in present machine
- Changes needed:
 - **Large Dipoles (340)**
 - **Arcs (250):** Reuse all (use add-on iron to change from “C” to “H”)
 - **Spreaders/recombiners (90):** replace all
 - **Quadrupoles (700):** 90% unchanged; replace 10%
 - **Steering dipoles (700):** no change

Power supplies

- Replace 15 of the 36 large (>100kW) power supplies
- Replace power supplies on ~20% of the quadrupoles



Project Status

CD-0 approved on March 30, 2004

Independent Project (“Lehman”) Review

- **July 12-14, 2005**
- ***“All of the requirements for CD-1 approval have been completed”***



Cost and Schedule

TPC range

- \$225M-300M
- Accelerator is ~1/3 of total

Begin construction	Spring 2008
Accelerator down	Summer 2010 thru spring 2011
Accelerator commissioning	Spring 2011
Re-start research program	Summer 2011
Start research at 12 GeV	Spring 2012



Summary

JLab is ready to implement a cost-effective project to upgrade its accelerator from 6 GeV to 12 GeV with the principal goal of investigating the underlying nature of quark confinement and other aspects of non-perturbative QCD

- **Add ten 100+ MV cryomodules plus supporting RF and cryogenics**
- **Upgrade the existing 5-pass recirculation beam transport system and add a 10th arc plus beam transport to a new experimental area.**

Accelerator construction & commissioning would last ~3 years

- **Includes ~1 year suspension of accelerator operations.**

Next steps

- **CD-1 approval in 1QFY06**
- **Securing a solid funding profile**

